SAMPLING APPARATUS

[0001] Technical Field

[0002] The invention relates to a sampling apparatus for introducing a liquid sample to a measuring unit.

[0003] Background Art

[0004] The sampling apparatus is used for measuring a density or a refractive index of various liquid samples, such as sucrose for food materials, drink, alcohol, and gasoline, and etc. Some sampling apparatus are configured to automatically operate the cleaning and the drying of a measurement path, in addition to the introduction of a sample to a measuring unit.

[0005] Fig. 8 illustrates an exemplified constitution of the sampling apparatus. The sampling apparatus is provided with a diaphragm type pump 301 for introducing a sample from a vessel 2 into a densimeter 1. At the start of introducing the sample, the pump 301 pumps dried air into the vessel 2, and thereby the liquid sample is discharged from the vessel 2 and introduced into the densimeter 1 through a pipe connecting the vessel and the densimeter 1. After the sample goes through the densimeter 1, it is delivered to an outside. The sample introduced into the densimeter 1 is measured, and then the pump 301 pumps

cleaning agents and desiccants in the measurement path one after another. After cleaning and drying the measurement path, a next sample is processed in the same manner.

[0006] At a site of controlling quality of petroleum products, the sampling apparatus measures plural kinds of samples, such as lubricating oil, light oil, or the like, in turns. Also at a site of quality control of the drink manufacturing, the apparatus measures finished-products and intermediate-products, such as juice, syrup of raw material of juice, and so on, in turns.

[0007] In case of measuring the various kinds of samples in turns, it is usual that the samples to be introduced into the measuring unit differ greatly in viscosity. If the pressure to be given to a sample were not changed depending on the sample by means of the pump, the sample cannot be introduced in the measuring unit, or the sample can be extracted excessively. To make matters worse, the sample introduced into the measuring unit will include air bubbles, this could have a bad influence upon the measuring.

[0008] The above-mentioned sampling apparatus is provided with a needle valve 302 and a switching valve 33 in order to adjust the air pressure sent from the pump 301 to the vessel depending on the viscosity of the sample. The flow rate of a suction path of the pump 301 is changed by the valves 302 and 303. If the viscosity of the sample is low, the switching valve 303 is closed. In this case, it is possible to set the flow rate to a very small value that is suitable for the sample, by means of a needle of the needle valve 302. If the viscosity of the sample is high, the large flow rate can be assured by opening the switching valve 303.

[0009] As described above, it is possible to adjust the speed of extracting the sample from the vessel 2 by using the needle valve 302 and the switching valve 303.

[0010] However, whenever the sample is changed, the setting of the valves 302 and 303 must be changed. If there are various samples, the changing operation is complicated. In addition, there is a possibility that a user makes an erroneous change or makes an unnecessary change.

[0011] Disclosure of Invention

[0012] In order to settle the aforementioned subjects of the prior art, the present invention has an object to provide a sampling apparatus by which various samples can be measured in a simple manner.

[0013] To achieve the object, the invention employs following configuration.

[0014] The sampling apparatus is configured to introduce a liquid sample by means of a peristaltic pump. A determining unit determines whether or not the sample is introduced into a measuring unit. To perform the determination, a limit sensor can be used, which is provided to a path for discharging the sample from the measuring unit. At using the limit sensor, the determining unit performs the determination based on an output of the sensor and a time from the sampling start. Even after a specific time elapses from the start of the sampling, if the limit sensor does not detect the sample, the determining unit determines that the sample is not introduced. A control unit controls the peristaltic pump based on the determination result. When the determining unit determines that the sample is not

introduced, the control unit controls the peristaltic pump to increase the sampling speed, for example.

[0015] As described above, the invention is configured to control the peristaltic pump based on whether or not the liquid sample is introduced into the measuring unit, and this makes it possible to introduce properly and simply various kinds of samples into the measuring unit in turns while avoiding the excess sampling and the mix of bubbles.

[0016] Embodiments of the invention are described hereinafter with referring to attached drawings. The following embodiments are examples that realize the invention, and do not limit the technical range of the invention.

[0017] Brief Description of the Drawings

[0018] Fig. 1 is a schematic block diagram of a sampling apparatus in an embodiment.

[0019] Fig. 2 is a sectional view explaining a nozzle and a sealing member of a vessel.

[0020] Fig. 3 is a sectional view explaining a nozzle and another sealing member of a vessel.

[0021] Fig. 4 is a diagram comparing the sampling time of the sampling apparatus of the present invention with that of a conventional sampling apparatus.

[0022] Fig. 5 is another diagram comparing the sampling time of the sampling apparatus of the present invention with that of a conventional sampling apparatus.

[0023] Fig. 6 is a diagram showing a measurement result when pure water and oil are measured in turns by means of the sampling apparatus of the invention.

[0024] Fig. 7 is a diagram showing each sampling amount.

[0025] Fig. 8 is a diagram explaining an example of a conventional sampling apparatus.

[0026] Description of the Preferred Embodiments

[0027] Fig. 1 shows a schematic block diagram of a sampling apparatus of the present invention.

[0028] The sampling apparatus is provided with a densimeter 1 for measuring a density of a liquid sample. A vibration type of a densimeter is used to the densimeter 1. The sample extracted from a vessel 2 is introduced into the densimeter 1.

[0029] In order to extract the sample, a peristaltic pump 3 is used. The peristaltic pump 3 sucks air that is dried in a dry cylinder 4, and pumps the dried air into the vessel 2. Thereby, the liquid sample is pressurized, and discharged from the vessel 2. The peristaltic pump 3 is used in order to pressurize the liquid sample, with the result that, even in case of any kind of sample or no matter how viscosity of sample from low to high, it is possible to extract an appropriate amount of sample. Additionally, there is no need to

adjust the flow rate by using the needle valve, and a precisely processed needle is not required.

[0030] A pipe 101 for delivering the sample from the densimeter 1 is provided with a limit sensor 5. The limit sensor 5 may be an optical sensor which is a transmission type and usually used to detect the sample. According to a signal from the limit sensor 5, it is possible to determine whether or not the sample is flowing in the pipe.

[0031] The limit sensor 5 is connected to a controller 6. The controller 6 controls the densimeter 1, the peristaltic pump 3, electromagnetic valves 7, 8 and 9. The controller 6 may be a control calculation unit such as CPU, and etc.

[0032] To start measuring the density, the controller 6 controls the electromagnetic valves 7 and 8 to establish a path from the dry cylinder 4 to the vessel 2 through the peristaltic pump 3. Hereupon, the controller 6 operates the peristaltic pump 3 by applying a control voltage to the peristaltic pump 3.

[0033] The control voltage applied to the peristaltic pump 3 by the controller 6 of this embodiment is any of two levels of voltage. Depending on a high level or a low level of the control voltage, an output of the peristaltic pump 3 goes up or down, and the sampling speed increases or decreases. The control voltage at the start time of the sampling is the lower level.

[0034] In case of the sample with low viscosity, the sample in the vessel 2 is smoothly introduced into the densimeter 1, and the densimeter 1 measures the sample according to the instruction from the controller 6.

[0035] After going through the densimeter 1, the sample flows in the pipe 101 before being discharged. As described above, it is possible to know whether or not the sample is flowing in the pipe 101 by the output of the limit sensor 5. When the controller 6 determines that a specific amount of sample flows in the pipe 101, it stops the peristaltic pump 3 to terminate the measurement of the density.

[0036] After terminating the measurement, the controller 6 cleans a nozzle 10 according to need. The nozzle 10 is used for pumping the air for pressurization to the vessel 2. When cleaning the nozzle 10, the controller 6 controls the electromagnetic valves 7 and 9 to establishes a path from a cleaner 11 to the nozzle 10 through a pump 12. The cleaner 11 is used for supplying a cleaning fluid and a drying fluid. The cleaning fluid and the drying fluid are supplied into the nozzle 10 one after another by using the pump 12, whereby the nozzle and the measurement path can be cleaned and dried.

[0037] Fig. 2 is a sectional view of the vessel to which the nozzle is inserted. The nozzle 10 is removably attached to the vessel 2 by a nozzle holder 201. A seal member 202 is used for sealing the vessel 2 and a member inserted into the vessel 2. In the drawing, the seal member 202 seals the nozzle 10 and the nozzle holder 201. The seal member 202 is provided with a shock absorbing rubber 203 and a cap 204.

[0038] The cleaning fluid to be used for cleaning the nozzle 10, such as toluene, has high solubility. When the sample is the fuel oil, the sample and the measuring path must be heated to about $60\,°C$ to $90\,°C$. The sealing member is required to be heat-resistant. Therefore, the sealing member 202 has a two-layer structure made of the seat and the shock absorbing rubber 203.

[0039] The shock absorbing rubber 203 employs a material like EPDM (Ethylene-Propylene-Diene-Monomer) with the heat-resistance and the elasticity, for the purpose of ensuring the air-tightness of various shapes of vessel.

[0040] The cap 204 is a seat member with the solvent resistance and the heat-resistance, and a Teflon system material is used to the cap 204, for example. The cap 204 can prevent the deformation of the shock absorbing rubber 203.

[0041] It is desirable to use the above mentioned seal member 202, however, a packing 205 can be used to the sealing member, too, as shown in Fig. 3. Only one packing 205 cannot prevent the leak for a long period. For instance, when the automatic measurement of the oil is performed continuously at the temperature, $80\,°C$, the packing must be changed every 20 days. It can be confirmed that, in case of the sealing member with two-layer structure, the life can be extended to over 90 days under the same condition.

[0042] After the cleaning and drying finished under the above-mentioned configuration, a different kind of sample can be measured in turn. Even when it changes from the low viscosity sample to the high viscosity sample, the controller 6 first applies the lower control voltage on the peristaltic pump 3 as mentioned above. Depending on the sample viscosity,

there is a possibility that the output of the pump is insufficient and the sample cannot be introduced into the densimeter 1.

[0043] In the sampling apparatus of the present invention, the controller 6 is provided with a timer 61 to count the time from the start of the sampling. The control calculation unit also works as a determining unit 62 according to the instruction from the software.

[0044] The determining unit 62 determines whether or not the sample is introduced in the densimeter 1. The determination is based on a value of the timer 61 and an output of the limit sensor 5. Even when the time from the start of the sampling elapses over a specific time, if the limit sensor 5 detects that the sample does not flow in the pipe 101, the determining unit 62 determines that the sample is not introduced into the densimeter 1.

[0045] When it is detected that the sample is not introduced into the densimeter, the controller 6 controls the peristaltic pump 3 to increase the sampling speed. In the embodiment, the sampling speed is changed by switching the control voltage from the low level to the high level. Such change makes it possible to introduce even the high viscosity sample in the densimeter 1.

[0046] Since the sampling speed can be changed automatically as mentioned above, it is possible to introduce various kinds of samples into the measuring unit in turns simply and reliably. In addition, it is possible to avoid the excess sampling and the bubble mix.

[0047] Even when the apparatus measures a low viscosity sample after a high viscosity sample, the sampling apparatus of this embodiment is configured so that the control voltage

at the sampling start is always set to the low level, and in result the sample is not extracted excessively.

[0048] Fig. 4 and Fig. 5 show each sampling time when the sampling apparatus of this embodiment and a conventional sampling apparatus shown in Fig. 8 extract respective two kinds of sample of which viscosities are known. In Fig. 5, a solid line corresponds to the sampling apparatus of the embodiment, while a dotted line corresponds to the conventional sampling apparatus. As shown in Figs. 4 and 5, while the sample viscosity that the conventional sampling apparatus can measure is 6000 mPa.s at the maximum, the sampling apparatus of the embodiment can measure the viscosity up to 30000 mPa.s. In the sampling apparatus of the embodiment, it is possible to reduce the sampling time sharply in any sample case.

[0049] Fig. 6 shows a measurement result when pure water and oil (viscosity 2000 mPa.s) are measured in turns. As shown in the example, the sampling apparatus of the embodiment can measure the sample stably even in case of measuring the low viscosity sample and the high viscosity sample in turns.

[0050] Fig. 7 shows a sampling amount when the pure water is extracted to 8 ml vial. Even when the measurement is performed repeatedly in such way, it is possible to obtain an extremely stable sampling amount at the sampling stop.

[0051] The above-mentioned embodiments will not restrict the technical filed of the present invention, and there will be many modifications and applications within the field in addition to the aforementioned embodiments.

[0052] For instance, without using the densimeter 1, another measuring unit can be employed.

[0053] The controller 6 and the determining unit 62 may be configured so as to be carried out by respective hardware.

[0054] The controller 6 may set the output of the peristaltic pump 3 to multi-levels or may change the output continuously.

[0055] In stead of the output of the limit sensor 5 and the value of the timer 61, the determination whether or not the sample is introduced may be based on the measurement result of the measuring unit.

[0056] In the sampling apparatus, it is possible to avoid the mix of the air bubbles. When the babbles get mixed, if the vibration is given to the path, the air babbles do not stagnate in the path. Therefore, it is possible to control the error of measurement without the stagnation of the air bubbles. For instance, the electromagnetic valve is provided to the pipe 101, and it may configure to open and close the electromagnetic value periodically.

[0057] Industrial Applicability

[0058] The invention can provide an effect that various kinds of samples can be introduced reliably and simply into the measuring unit while avoiding the excess sampling and the mix of the air bubbles. The invention is available to the sampling apparatus for various liquid samples.